Wild West Science Reporting

Pitfalls and Ethical Issues in the Reporting of Frontier Science

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Declaration

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Abstract[N1]

When reporting on new research or claims by scientists, the science journalist faces a number of pitfalls. For a number of reasons the journalist might produce a story which is inaccurate or misleading. Thus, when a scientist claims to have found a cure for cancer, the journalist needs to check himself before delivering the story.

In this paper I will examine a number of issues concerning the reporting of frontier science, or new research. In this realm it is particularly difficult to distinguish more reliable science from less reliable science. The problem is compounded by the vested interests of scientists, pharmaceutical companies and other interest groups. What the science journalist writes, influences public opinion, conceptions about science, and often affects people's decision-making regarding medical issues. There is thus a clear ethical aspect to science reporting.

I will try to show that an understanding of how science works is crucial to reporting science responsibly. In this regard the distinction between frontier and textbook science is of particular importance. Theoretical distinctions such as these provide useful tools for the interpretation of claims from the frontier.

The first chapter, then, will deal with theoretical concepts pertaining to how science works. In the second we will examine a number of examples of how reporting from the frontiers can go wrong. We will argue that a better understanding of science might have prevented many of the inaccuracies and misleading claims examined.

In chapter three we will attempt to list what can go wrong, and examine some of the possible consequences, thus outlining the ethical aspect of science reporting. Finally we will make a few suggestions and outline some guidelines which might contribute to more accurate and responsible reporting from the frontiers.

Opsomming[N2]

Wanneer daar oor nuwe navorsing of aansprake deur wetenskaplikes berig moet word, word die wetenskapsverslaggewer gekonfronteer deur 'n aantal moontlike slaggate. Om verskeie redes kan daar onakkuraat of misleidend verslag gedoen word. Wanneer 'n wetenskaplike dus berig dat daar 'n kuur vir kanker gevind is, moet die joernalis homself eers aan sekere beginsels herinner.

In hierdie skrywe sal ek 'n aantal kwessies te doen met die beriggewing van pionierswetenskap, of nuwe wetenskap, ondersoek. Op hierdie terrein is dit veral moeilik om tussen betroubare en minder betroubare wetenskap te onderskei. Die probleem word vererger deur die belange van wetenskaplikes, farmaseutiese maatskappye en ander belangegroepe. Dit wat deur die wetenskapsjoernalis berig word, beïnvloed publieke opinie en beskouings oor die wetenskap, en raak dikwels mense se besluitneming rakende mediese kwessies. Daar is dus 'n duidelike etiese aspek aan wetenskapsverslaggewing verbonde.

Ek gaan poog om te wys dat 'n begrip[N3] van hoe wetenskap werk, onmisbaar is vir verantwoordelike wetenskapsverslaggewing. In hierdie verband is die onderskeid tussen pioniers- en handboekwetenskap van besondere belang. Teoretiese onderskeide soos dié verskaf bruikbare gereedskap vir die interpretasie van aansprake uit die pionierswetenskap.

In die eerste hoofstuk sal 'n aantal teoretiese konsepte oor die werking van wetenskap verduidelik word. In die tweede hoofstuk sal 'n aantal voorbeelde van waar verslaggewing van [N4]pionierswetenskap verkeerd geloop het, bespreek word. Ek gaan argumenteer dat 'n beter begrip[N5] van wetenskap moontlik baie van dié onakkuraathede en misleidende aansprake sou kon voorkom het.

Hoofstuk drie sal dan poog om te lys wat verkeerd kan gaan, en sal sommige van die moontlike gevolge ondersoek. Hierdeur sal die etiese aspek van wetenskapsverslaggewing dus uitgestippel word. Aan die einde sal ek 'n paar voorstelle

maak, en probeer om riglyne uit te stip wat kan bydra tot meer akkurate en verantwoordelike verslaggewing van pionierswetenskap.

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Chapter 1 - Theoretical Basis

In the old Wild West, being a journalist [N7]was not easy. As on any frontier, it was hard to distinguish truth from myth. As in many westerns, the supposed good guys were not always the good guys, and neither were the bad the bad: sheriffs turned out crooked and outlaws became heroes.

These difficulties were further compounded by the limited means of communication. People told stories, these stories turned into myth; some traveller would hear a story, and the story was repeated a few settlements further. Thus it was possible for lies to prevail.

Yet despite the uncertainty facing the Wild West reporter, there was an actual series of events that he could try to reconstruct. If he took the time, he might discover that the sheriff and the outlaw were in on it together -[N8] or that the outlaw never really existed, that people were just making up stories about him, and that the only person benefiting from the myth was the bank manager.

Today, the science journalist faces much the same plight. Many scientists present research -[N9] some part of the establishment; some dissident, rogue manifestations of man's attempts to understand nature. Some scientists collude with pharmaceutical companies, while others hide or downplay weaknesses in their study design. Vested interests blur the line between pseudo and real science.

A science journalist cannot simply write everything he hears, or use news value as his sole criteria. If he does, he is a tabloid reporter, printing every story that comes in from the frontier if it "sounds good".

Science isn't that relative or subjective. Fundamental to the logic of science is the belief that we can distinguish between more and less accurate, between "this works" and "that does not".

The question is on what basis we can make such distinctions. In this chapter we will search for that basis in a number of theoretical concepts and ideas pertaining to the following: the nature of scientific inquiry, the nature of scientific knowledge, the difficulty of distinguishing real from pseudo science, and the opposition between frontier and textbook science.

In this paper, I will be arguing that an understanding of the fundamental ideas discussed in this chapter is essential to dealing responsibly with frontier science.

1.1 Karl Popper

1.1.1. Introduction

During the twentieth century, no philosopher has made as great a contribution to the philosophy of science as Karl Popper. His ideas have been recognised and celebrated by a number of scientists, and form the basis for much of modern thinking about scientific inquiry.

Popper was born in 1902 in Vienna, Austria. During the first half of the twentieth century, Vienna was seen by many as the intellectual capital of the west. Thus Popper was exposed to ideas as varied as that of Freud's psychoanalysis and Adler's individual psychology, as well as that of the philosophical group known as the Vienna Circle. He was especially impressed, however, by a lecture of Albert Einstein (http://plato.stanford.edu/entries/popper).

Popper was impressed with Einstein's critical approach to science. He contrasted this with the less scientific claims of psychoanalysis and Marxism. Even though the latter two claimed to be scientific, Popper felt that they were only paying lip service. What appealed to him about Einstein's theories was that they could be disproved or falsified (http://plato.stanford.edu/entries/popper [N10]).

So, for example, Einstein placed his theory of[N11] relativity on the line with Eddington's experiments. The experiments were designed to determine whether a ray of light is attracted by a solid body (http://plato.stanford.edu/entries/popper), in this case the sun. Had it been disproved, Einstein's theory of relativity would have been falsified. It was not, and thus the theory attained greater validity (http://plato.stanford.edu/entries/popper).

In contrast, however, Popper felt that psychoanalysis was unverifiable. Whatever happened, the psychoanalyst could find a way to explain it. Popper argued that Marxism fell at a similar hurdle. Even though predictions could be made on the basis of Marxist theory, and it was thus "scientific" in that sense, Popper noted that when predictions turned out to be inaccurate, Marxists always found a way to explain the error and rehabilitate the theory (http://plato.stanford.edu/entries/popper).

1.1.2. Falsification and the "Problem of Demarcation"

To Popper, the central problem in the philosophy of science is that of demarcation or, in other words, distinguishing between the "empirical sciences" and non-science. Amongst others, he considers mathematics, logic, and "metaphysical" systems to be non-science (Popper 2003, 11).

In his analysis of the problem in his book *The Logic of Scientific Discovery,* he starts by arguing against the idea of induction as the basis for scientific knowledge. In this regard, he draws on the work of the British philosopher David Hume (Popper 2003, 11), who argued that no certainty could be reached through induction.

A famous example of Hume's argument deals with a chicken which is fed on a daily basis by the farmer's wife. It would seem reasonable for the chicken to believe that when he sees the farmer's wife approaching in the morning, he will soon be fed. One day, of course, the farmer's wife does not bring food, but a knife - thus disproving the chicken's misguided idea of cause and effect. The fact that the coming of the farmer's wife had always in the past been followed by her giving him food, does not mean that the one caused the other. Popper gives another example: " . . . no matter how many instances of white swans we may have observed, this does not justify the conclusion that all swans are white" (2003, 4).

Popper thus accepts Hume's critique of induction, and continues to argue that, contrary to popular belief, induction is not the primary mode of scientific inquiry. According to him, a more suitable criterion of demarcation should be sought.

Popper thus replaces induction with falsifiability: for him, a theory is only "scientific" if it can conceivably be *dis*proved (Popper 2003, 18). When testing a scientific theory, in other words, the focus should be on trying to falsify the theory instead of verifying it. Only a test that conceivably refutes the theory, truly adds to its scientific validity. The higher the probability of the test refuting the theory, the more "scientific" the test.

[N12]Popper points out that, while theories *can* conclusively be falsified, it is impossible to verify any theory conclusively. We can never prove that a theory is true, but we can prove that it is false. Since falsification provides more certainty, he feels that it is the more adequate criterion for scientific testing (Popper 2003, 18):

> I shall not require of a scientific system that it shall be capable of being singled out, once and for all in a positive sense; but I shall require that its logical form be such that it can be singled out, by means of empirical tests, in a negative sense: *it must be possible for an empirical scientific system to be refuted by experience* (Popper 2003, 18).

Even if evidence has corroborated the validity of a theory over a period of time and the theory has withstood rigorous testing, it can never step into the realm of absolute certainty, " . . . for any conclusion drawn in this way may always turn out to be false" (Popper 2003, 4). There is always the possibility that evidence should arise that falsifies the theory.

We may nevertheless accept a theory as the most accurate or useful theory available to us on a certain matter. Consider, for instance, how Newtonian physics were maintained despite certain anomalies: only once Einstein's theory of relativity surfaced, was Newtonian physics relegated to the level of an outdated theory (http://plato.stanford.edu/entries/popper). But of course, in time, other theories might replace the older ones: "Theories are nets cast to catch what we call 'the world': to rationalize, to explain, and to master it. We endeavour to make the mesh ever finer and finer" (Popper 2003, 37-38).

Popper also draws a clear distinction between the strictly logical aspect of his theory of demarcation, as outlined above, and the practical methodological realities. In this regard he reminds us that a single refutation of a theory is often the result of mistaken observations (Popper 2003, 21) or a weak study design (http://plato.stanford.edu/entries/popper). Popper also notes that scientific observation is always theory-laden and selective (" . . . if I am ordered: 'Record what you are now experiencing' I shall hardly know how to obey this ambiguous order" [Popper 2003, 88]) and that with selective observation one could find "evidence" in support of just about any theory (He quotes Black: "A nice adaptation of conditions will make almost any hypothesis agree with the phenomena." [Popper 2003, 61-62]).

Thus the science journalist should keep in mind that scientists gather information selectively, that no theory can ever be absolutely proven, and that even if anomalies appear - one or two studies contradict the accepted scientific theory - this does not mean that the accepted theory is no longer the most useful one we have. In the next chapter we will consider some examples pertaining to these two points (see 2.1).

1.1.3. How Science Progresses

Popper rejects the idea that scientific theories develop from empirical observation and inductive reasoning on the basis of those observations. He argues that scientists' observations are guided by subjective interests, expectations, wishes, etc. (http://plato.stanford.edu/entries/popper). He also argues that there is nothing logical in the initial hypothesising of a theory. Instead, it suggests a leap of the imagination (Popper 2003, 8), an "intuitive idea" (Popper 2003, 34). Popper quotes Einstein as speaking of the "search for those highly universal laws . . . from which a picture of the world can be obtained by pure deduction. There is no logical path . . . leading to these . . . laws. They can only be reached by intuition, based upon something like an intellectual love ('*Einfühlung*') of the objects of experience" (Popper 2003, 8-9). Thus one might say that no theory is *a priori* more valid than another (http://plato.stanford.edu/entries/popper).

At any particular time we are faced with a multiplicity of possible theories. Here Popper identifies the crucial importance of critical thinking in the process of identifying the best theory (Popper 2003, 28). (The journalist faces much the same problem when faced with a fresh stack of research articles.)

Popper outlines a number of steps in the deductive process used to gage the validity of a theory:

1. Testing the internal consistency of the theory, thus exposing any contradictions or flaws in design.
2. Breaking up the theory into its empirical and logical elements. Making the logical argument explicit helps prevent confusing or misleading results.
3. Comparing the new theory with existing theories. If the new theory offers greater empirical content and predictive power, Popper argues, it will replace the existing ones.
4. Empirically testing the conclusions suggested by the new theory. If the predictions hold, the theory is corroborated, but never proven. If the predictions are shown to be inaccurate, the theory is falsified. (Remember, however, that even if falsified, the theory might nevertheless remain the best available theory) (Popper 2003, 9).

As indicated in 3 (above), Popper places great value on empirical content and predictive power. For Popper, theories should make as many and as specific predictions as possible. This leads to some interesting inversions of the traditional view of science which holds that, all things being equal, the more probable theory should be accepted. Popper argues that the more probable theory is also less specific and has less informative content; and, as a result, less predictive power. This also means that the more probable theory is also the less falsifiable one (http://plato.stanford.edu/entries/popper). Accordingly, Popper argues that the less probable theory is the more scientific one, since it can be tested to a greater degree (Popper 2003, 19).

As we have seen, Popper holds that no theory can ever be shown to be true. This view, based on his rejection of induction as ground for certainty, was seen by many as opening the door to relativism, uncertainty and a non-progressive view of science.

Popper tried to answer these concerns with the introduction of the term "verisimilitude" (truthlikeness). Verisimilitude describes the extent to which a theory approaches the truth. Popper argued that a theory could never be true, but added that verisimilitude allowed one theory to be closer to the truth than another. Thus the idea of verisimilitude allows science to be seen as progressive, without reverting to induction or the concept of absolute truth (http://plato.stanford.edu/entries/ popper).

Verisimilitude thus allows for the idea that science is making progress in the direction of truth. Popper saw this development as being characterized by an evolutionary struggle between rival theories: “We choose the theory which holds its own in competition with other theories; the one which, by natural selection, proves itself the fittest to survive” (Popper 2003, 91).

1.2 Henry Bauer

1.2.1 Introduction

In this section we will focus on Henry H. Bauer’s book, *Scientific Literacy and the Myth of the Scientific Method.*

Bauer’s ideas might at first seem rather extreme, and more conservative minds may not accept his views on the nature of the scientific method. All things considered, however, it is hard to argue against him. His rejection of the "scientific method" is not a rejection of science, but rather an essential and demystifying reappraisal of the nature and significance of science.

1.2.2 Scientific Literacy

It is widely accepted that scientific literacy in the west is at present extremely low, and studies in the United States seem to confirm this notion. This illiteracy is widely seen as being harmful to democracy (Bauer 1992, 1[N13]) and to people's ability to make informed decisions in areas such as healthcare, where science has a direct impact on people's lives. Scientific illiteracy in government and among policy-makers has a further detrimental effect on our society.

Scientific literacy tests generally test the following three components: (1) the substantive concepts within science; (2) the nature of scientific activity; and (3) the role of science within society and culture (Bauer 1992, 2). After analysing some such questionnaires, Bauer concludes that the tests themselves tend to be based on misconceptions of science (1992, 1-2). So, in the "nature of scientific activity" section, answers in accordance with the "scientific method" are taken as correct. But as we will see, there are some serious shortcomings in this view of science. By implication, then, the so-called experts that devise these questionnaires have themselves a limited understanding of the working of science (Bauer 1992, 1-2). Thus it seems likely that many journalists also believe in the myth of the method. What exactly this "myth" is, will be explained in 1.2.3.

Bauer writes,

> Clearly enough, these surveys of literacy require that respondents parrot the contemporary scientific majority view, even when that means subscribing to opinions that are logically incompatible with one another. Yet at the same time, respondents are supposed to view science as proceeding by a logically sound method!" (1992, 7)

According to Bauer this kind of contradiction is inevitable when working with the misconceived view of science as typified merely by its method, and ignoring the social component (1992, 2) (For an explanation of the social component, see 1.2.4.1).

Bauer argues that the actual working of science should enjoy a higher priority. For example, he suggests that a course in Science and Technology Studies (STS) might be more useful than the obligatory science course, say physics or chemistry, that many universities insist upon (1992, 17). He discards the notion that one can learn about the nature of science by studying a particular science, pointing out that in such a case we learn only about the successes (1992, 13). Textbooks ignore the mass of scientific research that comes to nothing (1992, 14). Thus, by only focusing on the successes, it seems reasonable that people will assume that science proceeds logically and is guided by the certainty of its method (1992, 15).

1.2.3 The Myth of the Scientific Method

"It is widely believed that the essence of science is its method," writes Bauer (1992, 19) This method is described as follows: ". . . systematic controlled observation or experiment whose results lead to hypotheses, which are found valid or invalid through further work, leading to theories that are reliable because they were arrived at with initial open-mindedness and continual critical skepticism" (1992, 19).

The scientific method could also be described in the following terms: " . . . empirical, pragmatic, open-minded, skeptical, sensitive to possibilities of falsifying; thereby establishing objective facts leading to hypotheses, to laws, to theories; and incessantly reaching out for new knowledge, new discoveries, new facts, and new theories" (Bauer 1992, 20).

Bauer calls this kind of view the "myth of the scientific method" (Bauer 1992, 20). He argues that such a view is incapable of explaining what really happens in science, and is useless as a guide for what we ought to do in science (Bauer 1992, 20). He justifies his criticism in a number of ways:

Firstly, Bauer examines the difference between chemists who consider theory to be more fundamental and those who consider experimental evidence to be more fundamental. As an example, he points to James Watson and Francis Crick's elucidation of the structure of DNA. Crucial to their discovery was the fact that certain substances were present in exactly equal amounts in DNA. However, experiments only showed that they were *approximately* equal. Thus Watson and Crick simply assumed they were equal for theoretical reasons. Strictly speaking, then, they did not follow the scientific method. Bauer also mentions other examples in which more attention had been paid to theory than to empirical fact (1992, 20-23).

For this reason, Bauer contends that "the classical and common view of science misconceives the actual relationship between theories and facts" (1992, 24); as a result, it "misconceives the nature of the scientific method - the things that scientists actually do" (1992, 24).

Secondly, there are also some problems inherent in the use of terms like "science", "scientists" or "scientific". These terms suggest that there is something very similar about all scientists - for example, the usage of the method. Nevertheless, there are huge differences between, for instance, astronomy, biology, chemistry and geology (Bauer 1992, 24). Some sciences are observational while others are experimental; some search for universal, timeless laws, while others examine development over time. The idea that all these sciences follow a single method seems untenable. They certainly do have some things in common, but most certainly not to the extent suggested by the myth of the method. According to Bauer,

> Once [N14]one had said that science is the study of nature, and that scientific knowledge is valid only as long as it is not contradicted by nature, one has said essentially all that is truly common, without qualification, among all the sciences (1992, 28).

Consider the following oppositions:

Different sorts of science:	
Young	Mature
Data-driven	Theory-driven
Data-rich	Data-poor
Experimental	Observational
Quantitative ("hard")	Qualitative ("soft")
	etc.

Different bits of science:	
Frontier science	Textbook science
Normal science	Revolutionary science

Scientists vary in being:	
Good	Poor
Competent	Incompetent
Outstanding	Mediocre
Creative	Uninspired
Interesting	Entirely ignorable
	etc.

(Bauer 1992, 29).

A closer examination of some of these oppositions illustrates the point more clearly. For example, consider the distinction between textbook and frontier science:

> What is in the texts is reliable: It is relatively uncolored by the personalities of those who originally conceived it. It is generally agreed to by almost all the experts. It is unlikely to need to be altered in the future . . . By contrast, science at the frontier is very unreliable: today's discovery often turns out tomorrow to have been an error (Bauer 1992, 32).

Thus to call both kinds of science "science" - and mean the same thing by it - is an oversimplification.

Bauer proceeds to point out at the hand of the oppositions above that "scientists are human" (1992, 32). The myth of the method places an almost superhuman expectation of rational, objective thinking on the scientist. In practice, of course, scientists are people, and fallible in the way in which all other people are (Bauer 1992, 32).

The myth is dependent to a large degree on the narrative offered by textbooks. Scientific textbooks read like success stories. Everything seems to follow logically and follow a specific method (Bauer 1992, 34). In practice, however, the textbooks from which we all learn, represent only a very small part of the actual practice of science (Bauer 1992, 35). We do not see all the failed studies; neither is it emphasised, for instance, that Newton used "fudge factors" (Bauer 1992, 36). Thus basing one's understanding of science on what one reads in science textbooks is bound to reinforce the myth.

Bauer does not suggest that we discard the myth of the scientific method. Instead, he argues that it should be maintained as an ideal. Objectivity should be strived for, but it should also be realised that scientists can never be completely objective. The scientific method should thus be seen as a myth useful in guiding our behaviour, but not to be confused with reality.

1.2.4 Better Models

Having pointed out a number of problems with the commonly held view of science as being defined by its method, Bauer goes on to suggest a number of more adequate ways of thinking about science.

1.2.4.1 Science as Puzzle-building

He starts by outlining Michael Polanyi's model of science as a jigsaw puzzle. If a number of pieces are shared out among each of a number of scientists, not much success would be forthcoming if the scientists were to work separately. The chances that they could make significant headway with the few pieces at their disposal, would be small.

The solution is to let the scientists work within sight of each other. This way they can see what progress others are making, and adjust their own work to the new possibilities opened up by the advance (Bauer 1992, 43). Bauer explains: "Under this system, each helper will act on his own initiative, by responding to the latest achievements of the others, and the completion of their joint task will be greatly accelerated" (Bauer 1992, 43).

Such a joint venture would lead to an outcome that was unpremeditated by any of the particular members of the group. Bauer also points out that since the end is unknown, progress can only occur stepwise, and not all at once. Progress in building the puzzle would be most successful if the consequent piece is fitted by the person most competent to do so. If the whole project was under the leadership of a single person, progress would slow dramatically (Bauer 1992, 43). The model points out beautifully how different inputs, perspectives and a variety of minds are required to jointly achieve the greatest success.

Bauer summarizes the argument as follows:

> Polanyi's metaphor, straightforward as it may seem, is capable without further ado of illuminating salient features of science: that modern science began when cooperation among scientists became widespread and systematic; that modern science is a quite particular sort of cooperative venture, working most successfully when autonomous, that what really constitutes pseudoscience is isolation from the scientific community; why science cannot be successful and also produce what ideologues want (1992, 43-44).

The puzzle metaphor thus places great emphasis on science as a communal activity. Instead of simply being seen as relating to the physical reality, science is placed within a cultural, intersubjective realm. This shift in focus allows a startlingly close parallel to philosophical concepts of truth: during the last century the focus in philosophy has also shifted from truth as objective to an understanding of truth as a social construct.

1.2.4.2 The Filter

The working of science could further be elucidated by the concept of a knowledge filter. The filter focuses on the practical working of science and how we come to view certain claims as scientific and others as non-scientific. The filter is compatible with the puzzle model, and thus could simply be seen as a further refinement.

In short, the filter shows how knowledge moves from being subjective and unreliable to being objective and reliable. At the top of the filter, we start with all human traits. Graduate and undergraduate training filters out nonsense, stupidity, and pseudo-science. The next level is frontier science: here bias, error, and dishonesty are filtered out. Next, mistakes, uninteresting research and fraud are filtered out in the publication of primary literature such as research papers and abstracts. From all the primary literature there then emerges secondary literature, mostly in the form of review articles. Review articles manage to filter out many of the mistakes which might still be present in primary literature. Over time, further inadequacies are filtered out, and what we are left with, is textbook science. Thus we have moved from highly unreliable to very reliable scientific knowledge. Today's textbook science will of course be replaced by new textbooks in future (Bauer 1992, 44-47).

The filter provides us with an understanding of how, through an intersubjective man-made structure, humanity has managed to find a way of distinguishing between varied scientific claims. Bauer argues that the success of science could much rather be ascribed to the existence of the filter and the cooperative activity of science than by recourse to the idea of a single scientific method (1992, 55). He quotes John Ziman: "Science seeks to obtain a consensus of rational opinion over the widest possible field" (Bauer 1992, 50). This consensus is reached by means of the filter.

1.2.5 Pseudo-science

The problem of distinguishing between science and pseudo-science has plagued philosophers of science for a very long time. Bauer suggests that this problem is due to the myth of the method (1992, 57).

If science was essentially its method, other fields that we consider to be pseudo-science could also lay claim to the label "science": one could, in theory, use the scientific method to investigate claims of alien abduction or the accuracy of astrological predictions. Bauer argues that, even though these investigations might not hold much in the way of meaningful results, if they followed the scientific method one would have to regard the practitioners as "scientists". For this reason, Bauer suggests that the distinction between science and pseudo-science should not be made on the basis of whether or not someone is using the method (1992, 57-58).

Bauer also suggests, however, that the sharp distinction many critics try to find between science and pseudo-science is untenable. Over time, some subjects might move from pseudo-science to science, as seems to be the case with, for instance, acupuncture at the moment (1992, 60). The process is not, however, simply one that proceeds logically and according to the method. Instead, the distinction might better be understood as a social construct, in terms of the filter.

It might take time for something to gain acceptance, but this delay is essential to the working of science (Bauer 1992, 61). Science requires both innovation and conservatism, for without innovation progress would be unbearably slow, while without conservatism there is no way of weeding out the bad science (Bauer 1992, 59).

1.2.6 Science as a Map

One of the popular fables about science is that science deals in absolute facts. This is never the case. Scientific knowledge is never absolute or final. New evidence might always refute currently held beliefs (Bauer 1992, 63).

Philosophers of science have also placed great emphasis on the theory-laden nature of facts. Bauer uses the example of a mountain. That the mountain is there, could be considered a fact. But no-one is interested in it merely because it is there. The "fact" of the mountain connotes a number of different things for different people. For some, it is a creation of God; for others it might be an interesting geological site, and for others an interesting climb. The point is that the same fact means different things to different people (Bauer 1992, 65).

Bauer illustrates the point at the hand of evolution. When some scientists claim that evolution is a fact, they are really claiming a lot more than what can actually be proven (1992, 63). Some facts and observations suggest that evolution is currently the most convincing account of life on earth (1992, 66) This does not mean that evolution is a fact. Instead, evolution is simply the most convincing theory we have.

Bauer argues that thinking about science in terms of facts and theories has certain limitations:

> Science does contain enormously reliable knowledge, but it is not of the sort, 'The thing *A* exists' (a fact) or of the sort '*B* causes *C* to happen' (a theory); rather, scientific knowledge is of the sort: 'When one (anyone) does *P*, then *Q* happens' (almost all the time, under certain circumstances) (1992, 67).

Rather than thinking in terms of facts and theories, one might think of scientific knowledge as a map. Thus science is simply a guide to reality, and not reality itself. The map shows that if you do this, this will happen (Bauer 1992, 68). If you add these two chemicals, they will react and deliver such and such products..

A metro map is used to elucidate the metaphor. The map does not actually represent the metro system as it is, that is to say, it in no way attempts to be an exact representation. Instead, the map indicates certain places with dots and tracks with lines. The specific curves and relations on the map might differ drastically from the actual metro system, but this does not matter. What is important is that the map is a reliable guide to using the subway. Similarly, even though science does not provide us with absolute facts about the world, it is nevertheless a reliable guide (Bauer 1992, 68).

Strikes, accidents, an earthquake or a nuclear strike might render the metro inactive. In such a case the map would lose all or some of its use (Bauer 1992, 70). Furthermore, places get renamed, for instance. Thus the map metaphor incorporates the uncertainty and continual possibility of change within science. Advances in science might thus be seen as the development of more accurate maps which allow us to plan our travels more efficiently: "Scientific knowledge . . . is map-like rather than fact-like" (Bauer 1992, 71).

Bauer continues to outline a number of fables concerning science. They are, amongst others, the belief that successful prediction proves a theory right (1992, 71), that science is (or should be) open-minded (1992, 73), that science is self-correcting (1992, 82), and the idea that great scientists can speak for science (1992, 85).

1.2.7 Textbook and Frontier Science

> Textbook science is uncontroversial . . . We all learn science from textbooks, and we can hardly fail to be impressed by the range and reliability of the knowledge that has by now been amassed and by the power of the theories that orchestrate that knowledge (Bauer 1992, 103).

Bauer points out that though we are impressed by textbook science we hardly remain excited about it. Instead, he argues, what we do get excited about are the so-called new discoveries and breakthroughs in science:

> What we get excited about is also what gets into newspapers and the magazines and onto television. But what we mostly fail to realize is that what we get excited about - namely the frontier stuff - is quite a different sort of science from the textbook variety . . . Frontier science is very *un*reliable. The wobbling star soon turns out not to be wobbling at all; . . . The 'fastest spinning object in the universe' turns out instead to be an ordinary TV set interfering with the radio signals studied by astronomers (Bauer 1992, 103).

Bauer continues:

> Most of the miraculous science that gets headlines today fades away relatively unnoticed by next week or next month or next year, as it has to run the gauntlet of the scientific community, as others try to use the result or to repeat it (1992, 104).

For Bauer the problem is located in the fact that we use the word "science" for reliable textbook science as well as for unreliable frontier science: "So we fall into the very bad habit of taking the frontier stuff as being as reliable as the textbook stuff, and that has some quite debilitating consequences" (1992, 104).

1.2.8 Fraud in Science

In recent years significant concerns have been expressed about fraud in science. Bauer points out that the fraud is situated on the frontiers of science and not in the textbooks. It is ill-conceived to judge all of science by certain discrepancies on the frontiers (1992, 104).

As the particular scientific claims move through the filter, mistakes are weeded out. Other scientists try to use the fraudulent science and find it to be inaccurate. In short, the filter is so designed as to prevent the proliferation of fraud. Bauer points out that in some cases fraud might go unnoticed for a long time, when the fraudulent claims are of little interest to other scientists and thus manage to avoid scrutiny. Either way, such claims will not make it into the textbooks (1992, 104).

1.2.9 Medicine

The misconceived notion of frontier science as credible has had some particularly harmful consequences in the field of medicine: "The search for new medicines offers many contemporary instances in which wishful thinking ignores that frontier science is not reliable knowledge" (Bauer 1992, 108-109).

As a response, societies have developed drug screening authorities (Bauer 1992, 109) like the Federal Drug Administration in the United States. In effect, such authorities ensure that a drug or treatment first passes some way through the filter before it is made publicly available. Making new drugs available without them first going through the necessary tests, would in the vast majority of cases have dire consequences (Bauer 1992, 109).

Bauer writes, "Urging that new drugs be approved quickly is the same as urging that high levels of risk be accepted; but that is not what is said (or even believed)" (Bauer 1992, 109). It is in the short term interest of drug companies to get their drugs out as quickly as possible. Many people with serious diseases fall prey to unrealistic expectations of what a drug can do for them (Bauer 1992, 109). The media plays a pivotal role in the formation of these views, as we will see in 2.2.

As an example of what might go wrong, Bauer refers to the case of the tranquilliser thalidomide. The drug, given to pregnant women, was widely available outside the United States. Within the United States, people complained that it was taking too long for the drug to be approved. Eventually it turned out that the drug induced serious birth defects. In this case, the caution showed in not rushing to approve the drug spared a large number of American women the side-effect (1992, 110).

1.2.10 Science in the News

Bauer points out that the media is primarily interested in frontier science. This is covered under the heading "science", thus connoting objectivity, reliability and the scientific method (1992, 114). According to Bauer, the problem is aggravated by the media's lack of follow-up stories (1992, 114). So-called breakthroughs or new discoveries are reported, but subsequent correction often ignored: "Just as over other matters, so too in science: the media focus on aberration, not on context, perspective, or what is normal" (1992, 114).

In most cases, Bauer argues, the public can make allowances for the way news is reported. In the case of science, however, few people possess the critical faculty and the necessary understanding of the working of science not to be misled: ". . . on matters of science, most of the audience lacks the personal experience and technical background to make allowances for the media's bias toward instancy" (1992, 114).

The problem facing the science journalist is thus extremely complicated. He has to report from the frontiers of science where claims are notoriously dubious. He has to balance the editor's desire for breakthroughs and novelty with the need to communicate science as accurately as possible. But to keep things in perspective, to be capable of understanding the context of particular claims, the science journalist himself needs to understand the distinction between frontier science and textbook science. It is in these murky waters of fraud, wishful thinking, and vested interests that the ideas discussed in this chapter are essential if the journalist is to act responsibly.

1.2.11 Public Policy

Bauer contends that the lack of understanding about the distinction between frontier and textbook science is most harmful in the realm of public policy (1992, 115). He outlines a number of cases (cf. 1992, 115) in which large amounts of money have been spent on claims made at the frontiers. Such investments are by definition speculative.

Policy-makers often lack the scientific background or understanding of how science works to make informed choices. Their decision-making is thus based on the advice of a few representatives of science and their own misconceptions. It is thus highly unlikely that funds at the disposal of policy-makers are being put to optimal use. The implication is that society would benefit greatly from an increased awareness of how science works amongst policy-makers (Bauer 1992, 116).

1.3. The Relevance of Theory for the Science Journalist

It must be acknowledged that much of what goes wrong in the reporting of frontier science are caused by factors such as the limited space allowed for the story, limited time, and the need to write something that sells. In other cases things go wrong on a much more fundamental level.

A journalist might for example have an inadequate understanding of the distinction between frontier and textbook science, or journalists might not express the necessary doubt concerning the results of a new study. Failures like these can lead to inaccurate and misleading reportage.

A journalist familiar with the filter model might understand that it is irresponsible to write about new cancer research suggesting it may deliver a cure. The journalist needs to take a step back and realise that if every claimed cure turned out really to be one, the world would be a much healthier place than it is.

Science journalists are on the border between a number of systems. Firstly, they find themselves within a media environment. They come to understand the pressure to deliver interesting and novel stories. They work under pressure and are constantly pushed to deliver stories that will sell newspapers.

On the other hand, science journalists find themselves in the world of science. Judging by science reporting in general, journalists have a very partial understanding of the workings of this system. Alternatively, they might simply consider the values of the newsroom to be more important than those in the scientific world.

Thirdly, the science journalist finds himself in the wider society. Besides the newsroom's insistence on entertaining and the scientific insistence on accuracy, there is a readership whose decision-making is influenced by what the journalist writes. Promising a cure might stimulate hope; claiming the virtues of a drug might increase its use and impact the manufacturer's stock price.

Thus, the myth that science writing is straightforward and simply involves paraphrasing journal articles, cannot hold. The journalist is part of a complex system in which there is no neutral ground. He is either going to simplify too much or too little, convey too much or too little doubt, or find himself implying things he did not mean to. As if that is not enough, he has to deal with the varied ways in which his article might be interpreted.

The point is that science reporting is a complex issue and one needs to understand the process as well as possible so as to be capable of making responsible and informed decisions.

Popper and Bauer's arguments serve to provide a theoretical basis from which one might achieve a better understanding of science. This is particularly important when reporting from the frontiers, for frontier science has by definition not gone through the filter. This in itself is an invaluable realization.

It is essential to understand what frontier science is, why it is not reliable, and what the process is by which it might become more reliable. It is also essential to note that fraud, over-optimism, and inaccuracy are particularly common on the frontiers. An understanding of these and other misconceptions, as outlined in 1.2, would in most cases lead to more informed and responsible reporting.

1.3.1 Popper vs Bauer

It might be pointed out that Popper's understanding of science is not quite consistent with that of Bauer. Popper's emphasis on falsification is rejected by Bauer. For Bauer there is no central method or way in which science works. Nevertheless, one might learn much from both thinkers. The idea is not to present either as representing the "ultimate truth about science", but instead to present a number of ideas that may contribute to a better understanding of the practice of science.

Even though Bauer rejects the notion of science functioning in accordance with a particular method, he maintains that the method nevertheless remains a noble ideal. Decision-making within science, through peer review, is often justified by invoking the scientific method. In this regard, Popper's focus on falsifiability is crucial. In most cases one might indeed say that if something is not conceivably falsifiable, we will not consider it science.

On the other hand, focusing solely on falsifiability fails to account for much of the actual practice of science, in particular its social aspect. And as we have seen, science is to a large extent a social activity.

Chapter 2 - Examples

In Chapter 1 we considered a number of theoretical ideas about science, and distinguished between science and pseudo-science. In this chapter our attention turns to the practical. We will examine a number of actual cases in which the reporting of science has gone wrong, using the ideas explored in Chapter 1 to illuminate matters.

Note that this chapter, or paper for that matter, in no way aims to offer a quantitative view of the prevalence of misreporting from the frontiers. The examples below should rather be seen as examples of various things that could go wrong. In Chapter 3 we will venture a more thorough appraisal of what goes wrong, what kind of values and structures allow it to do so, and the implications of these problems.

2.1 Vitamin Supplements

It seems to be commonly accepted that the use of vitamin supplements offers some definite health advantages. Thus, when headlines appear claiming this is not the case, most readers would be interested. Such a story certainly sells newspapers, but it is my contention that we should tread carefully in such cases. When any news from the frontier clashes with previous accounts, we should take special care in checking its validity.

On 6 July 2002 an article titled "MRC/BHF Heart Protection Study of antioxidant vitamin supplementation in 20 536 high-risk individuals: a randomised placebo-controlled trial" appeared in the British medical journal, *The Lancet.*

The study, done by the Heart Protection Study Collaborative Group, aimed to estimate the effect of anti-oxidant vitamins on a group of high-risk patients over a five-year period. In this study, "20 536 UK adults (aged 40-80) with coronary disease, other occlusive arterial disease, or diabetes were randomly allocated to receive antioxidant vitamin supplementation (600 mg vitamin E, 250 mg vitamin C, and 20 mg ß-carotene daily) or matching placebo" (Heart Protection Study Collaborative Group 2002).

The study showed no significant advantages related to the use of the particular anti-oxidant vitamins. According to the study interpretation:

> Among the high-risk individuals that were studied, these antioxidant vitamins appeared to be safe. But, although this regimen increased blood vitamin concentrations substantially, it did not produce any significant reductions in the 5-year mortality from, or incidence of, any type of vascular disease, cancer, or other major outcome" (Heart Protection Study Collaborative Group 2002).

It is of extreme importance to point out that the study focussed on people who were already at high risk, and only tested a particular combination of vitamin supplements. Thus the conclusions of the study cannot be claimed to be universally applicable, or to pertain to people at low risk, or other combinations of vitamins.

As one might expect, the article sparked a series of newspaper and online articles. Interestingly, most of these appeared in the United Kingdom. Whether this is simply a reflection of the fact that *The Lancet* is a British journal, or indicative of a particular weakness in British science reporting, is unclear.

Consider the following lead from *The Guardian:*

> **Researchers doubt value of vitamin pills**
> *Supplements do not cut risk of illness, says study*
>
> Millions of people taking vitamin supplements are probably wasting their time if they think the pills will stave off heart problems, strokes, cancers, and other potentially fatal diseases, researchers said yesterday (http://www.guardian.co.uk/uk_news/story/0,3604, 749489,00.html).

The headline is a gross generalization. Even though some might argue that it is in the nature of headlines to be generalizations, since they are required to be short and compact, the price of misinforming is too great. In truth, the researchers only doubted the value of a particular combination of vitamins, and only when used by high risk patients.

The line "Supplements do not cut risk of illness, says study" and the lead paragraph carry the misinformation further. As we will see later, there are very good reasons to believe that vitamins indeed do prevent certain diseases and illnesses. What we have here is a headline and lead that completely misrepresent the study and the possible implications thereof. If someone were only to read this far, they would be severely misinformed. The study is taken completely out of context.

In the second paragraph, however, the piece is to some extent redeemed:

> Daily doses of vitamins C and E and beta-carotene administered to more than 10,000 patients at high risk of vascular disease over an average of five years did nothing to reduce the threat of death or illness (http://www.guardian.co.uk/uk_news/story/0,3604, 749489,00.html).

In this paragraph and the rest of the article, the *Lancet* study is quite accurately represented. Nevertheless, it is only in the very last paragraph that a critical view on the study is taken:

> A spokesman for the Health Supplements Information Service said vitamins had widely proven benefits when taken by the general population as a supplement to a balanced diet or to boost nutrients. They were not intended over a short time to treat or prevent serious illnesses among people at high risk of heart disease. The study had covered a narrow group (http://www.guardian.co.uk/uk_news/story/0,3604, 749489,00.html).

Had the intention of the article been to inform in a scientifically informed way, qualifiers such as these would have been placed much higher in the piece. This last paragraph is not in conflict with the study under discussion; instead it is simply a more sober interpretation of its results, and unfortunately the more sober interpretation is usually also the less exciting one. Putting qualifiers right at the top of an article just does not sell very well. What we have here is thus an excellent example of the value of informing being sacrificed for that of entertainment.

Consider the following from the 5 June 2002 edition of the *Daily Telegraph*[N15]:

> **Vitamin pills a waste of time and money, says study**
>
> Vitamin pills are 'a waste of time' and do not reduce the risk of heart disease or cancer, according to one of the biggest studies into food supplements.
>
> A five-year study involving more than 20,000 people found that a daily dose of three vitamin supplements made no difference to heart disease, cancer or mental decline. Prof Rory Collins, a co-author of the report at Oxford University's Clinical Trial Service, said: 'Over five years we saw absolutely no effect. Vitamin pills are a waste of time.
>
> . . . There was no evidence of any protective effect against heart disease, cancer or any other outcome. They are safe, but they are useless' (http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2002/07/05/nvit05.xml).

As in the *Guardian* article, we are faced with an extreme case of generalization. Once again the headline and lead paragraph make no mention of the fact that only a particular combination of vitamins was tested, or that they were only tested on a group of people at high risk.

The phrases "according to" and "says study" are misleading. In no way is the study saying that all vitamin supplements are a waste of time. But that is clearly being implied here. The only conclusion one can draw is that the reporter either did not understand the study, or chose to ignore the facts and write the story in a way that would make for more interesting reading.

It is interesting to note that the crucial information, that the study was conducted on group of people at high risk, is not mentioned at all. The group is only defined as "twenty thousand people aged 40 to 80". Thus, even a highly critical reader might be misled by the findings as they are represented in this piece.

As in the *Guardian* article, the piece does end with a qualifier, but as with the *Guardian*, the qualifier should have been placed much earlier:

> Dr Ann Walker, a food nutritionist at Reading University and a spokesman for the British Proprietary Association, which represents the food supplement industry, said the doses of vitamins might have been too low to help people already suffering from chronic heart disease.
>
> For other diseases such as cancer, what matters is a lifetime's intake of anti-oxidants, not what happens over five years," she said (http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2002/07/05/nvit05.xml).

Consider the following from the *BBC News* website.

> **Vitamin pills a 'waste of money'**
>
> Taking vitamins to protect against disease is a waste of money, according to a report.
>
> The study said that the millions of people taking daily doses of vitamins C and E and beta-carotene were not protecting themselves from cancer, heart problems, strokes and other potentially fatal diseases (http://news.bbc.co.uk/2/hi/health/2096672.stm).

Here we see the same generalization as we did in the other articles. However, the BBC piece does well to include the following:

> A spokesman for the Health Supplements Information Service said vitamins had widely proven benefits when taken by the general population as a supplement to a balanced diet or to boost nutrients.
>
> He said that they were not intended to be used over a short time to treat or prevent serious illness among people at high risk of heart disease.
>
> He said: 'Vitamins, including antioxidants, play a general preventative role with health' (http://news.bbc.co.uk/2/hi/health/2096672.stm).

In the above, three crucial points are made explicit: that the study dealt with high-risk individuals, that a five year period may be too short, and that vitamins should be seen as generally preventative and not as treatment for the prevention of serious diseases.

The article continues:

> A spokesman for Boots said: 'The report only looks at the benefits of vitamins and supplements for preventing chronic illness.
>
> 'Vitamins and supplements are not intended to treat or prevent serious illness.
>
> 'Supplements are essential for many people who find it difficult to ensure that they get the right amount of essential vitamins and minerals in their diet.
>
> 'Studies have shown the benefits of supplementing diets with vitamins for health maintenance' (http://news.bbc.co.uk/2/hi/health/2096672.stm).

Thus we see that even though the BBC article has a misleading lead, the article contains much more critical material than the previous two we considered. The reader is offered a much more balanced account of what the study was about and what its relevance might be.

The *Lancet* article, though a bit further down the filter than frontier science, is still far from the textbooks, and therefore its claims are still rather unreliable. Putting enough critical material into your report, helps bring this across. The BBC piece does this very well, whereas the pieces from *The Telegraph* and *Guardian* fail miserably.

The best headline I found concerning this particular study was from *New Nutrition Business*: "Antioxidant vitamins: no effect on disease in high-risk people?" (http://www.new-nutrition.com/news.asp). This headline is good for a number of reasons:

1. It identifies the specific kind of vitamin supplements.

2. It explicitly states that the study dealt with high-risk patients.
3. It states that the study dealt with the effect of vitamins on disease.
4. The question mark makes it clear that nothing has conclusively been proved.

Having looked at how a number of publications reported on the study, we will now turn our attention to a number of critical remarks concerning the study itself. Most of these points were not picked up in the mainstream media.

Shortly after the publication of the *Lancet* article, the Canadian Health Food Association asked its advisory to comment on the validity of the study. On 18 July 2002 the Canadian Health Food Association published a piece called "Research Stating Vitamin Supplements Useless for Cancer/Heart Disease BAD SCIENCE". In it, the *Lancet* study was criticised by a number of experts. Below are a number of quotes from the article.

> 'The fact . . . [is] these people were in poor shape to begin with, to think that making them better with these few supplements is ridiculous,' says Dr. Roger Rogers MD. 'It is probably inappropriate to study people who are already ill. It's not a fair trial' (Canadian Health Food Association 2002).
>
> Dr. Michael Murray, MD, concurs and adds that the study doesn't take into account the latest antioxidant research. 'My major issue with these sorts of studies is that it takes a very simplistic view of the antioxidant system of the body . . . researchers often focus on the effects of just one nutrient or a collection of only three, as in the current study . . . it seems that many researchers become too focused on the tree instead of looking at the forest because they fail to understand the importance of the way that individual antioxidants interact with the entire antioxidant system of the human body to produce their antioxidant benefits' (Canadian Health Food Association 2002).
>
> Antioxidants like vitamins C and E, and beta-carotene require partner antioxidants that allow them to work more efficiently. And scientists have discovered that it is quite easy for one antioxidant nutrient to become damaged if it's used alone. Studies looking only at vitamin E's ability to reduce cancer and heart disease are often faulty because they fail to factor in the critical partnership between selenium and vitamin E, not to mention the interrelationship between vitamin E and Coenzyme Q10. In the British Heart Protection study half of the patients were on statin drugs known to lower Coenzyme Q10, thereby

> compromising the benefits offered by vitamins C and E (Canadian Health Food Association 2002).
>
> Today, Californian researcher Dr. Matthias Rath, credited with proving the link between vitamin deficiency and cardiovascular disease, went as far as to say the study design compromised its integrity. This, based somewhat on the fact the study was partly funded by Merck, manufacturer of the statin drug Zocor, which was used in the study. Possible inaccuracies within the placebo groups and vitamin C doses selected for the study were also mentioned. He concluded, 'The findings (of the British Heart Protection study) contradict the basic scientific understanding of how vitamins work in the body. However, thousands of research studies exist that prove the health benefits of vitamins and other essential nutrients in preventing disease' (Canadian Health Food Association 2002).

The above quotes outline a number of critical points about which science writers in the mainstream media seem to have simply been unaware of. Either they lacked the necessary knowledge of the subject to pick up on these issues, or they simply neglected to ask the right questions of the right people. Either way, what seems to have been a serious flaw in the design of the *Lancet* study has gone completely unnoticed amongst British science writers.

These points were picked up by a number of scientists, yet the British media remained oblivious. In defence one might point to factors like the need for immediacy, limited space for the story, and competition among publications as possible justification. The point, however, is that the ideal of accurately informing the public is far from being fulfilled.

The generalizations that appeared in the British press are further contradicted by a review article that appeared in the *Journal of the American Medical Association* (*JAMA*) on 19 June 2002, a matter of weeks before the appearance of the *Lancet* article.

The *JAMA* article, titled "Vitamins for Chronic Disease Prevention in Adults: Clinical Applications", examined the results of more than 30 years of research into vitamin supplements. The conclusions put headlines like "Vitamin pills a waste of time and money, says study" in a very different light.

The *JAMA* article made the following recommendations:

> We recommend that all adults take one multivitamin daily. This practice is justified mainly by the known and suspected benefits of supplemental folate and vitamins B_{12}, B_6, and D in preventing cardiovascular disease, cancer, and osteoporosis and because multivitamins at that dose are safe and inexpensive (Flecher, R.H. & Fairfield K.M. 2002).

The article continues:

> Overall, there is strong evidence that vitamin E does not substantially decrease cardiovascular mortality, at least when taken throughout a period of a few years by patients with known coronary artery disease or who are at high risk. However, the observational studies showing a protective effect of vitamin E were all among lower-risk populations, and there are no trial data from similar populations. Vitamin E may still be useful in primary prevention when taken throughout long periods. In addition, some subgroups, including patients receiving dialysis, may benefit from supplementation (Flecher, R.H. & Fairfield K.M. 2002).

Even though a review article is not quite textbook science, it is much further down the filter than research studies. The results of the *JAMA* article thus represent what we know about vitamin supplements with much more validity. For journalists to report the *Lancet* study as they did, flies in the face of the most compelling evidence we have.

We could say that, in as far as we can determine, vitamin supplements should probably be used by most people, and hold multiple health benefits. Thus, when reporting that "vitamin pills are useless", one might be advising people to act in a way which compromises their health.

2.2. Cancer Cures

Some of the toughest stories for science journalists to write, are those relating to possible cures or new treatments. Often scientists make rather small advances in search of a cure. On the one hand these advances must be reported; on the other it is hard to keep a particular advance in perspective. A rather minor advance may be represented as a major one and stimulate false hope under those suffering from the particular disease or affliction.

It is hard to estimate the relevance of a particular advance or set of new findings. It is even harder to give the findings appropriate weight in your writing. Of course, the temptation is to overplay the significance of an advance to grab headlines, get people interested, and increase circulation. On the other hand, the journalist has an ethical responsibility not to misrepresent the possibility of a cure.

The following headline and lead appeared on the front page of the 3 May 1998 edition of the *New York Times*:

> **HOPE IN THE LAB: A special report.; A Cautious Awe Greets Drugs That Eradicate Tumours in Mice**
>
> Within a year, if all goes well, the first cancer patient will be injected with two new drugs that can eradicate any type of cancer, with no obvious side effects and no drug resistance - in mice (http://query.nytimes.com/search/article-page.html?res=9F04E6D6113EF930A35756C0A96E958260).

The piece by Gina Kolata provoked an enormous amount of discussion and criticism. It also sparked a spate of similar articles all over the American and world media, thus in many cases creating false hope.

The article outlines the use of angiostatin and endostatin in cutting off the blood supply to tumours. Together these two drugs successfully cure cancer in mice. What this means to humans is, however, highly questionable.

In the four years following the publication of Kolata's article, however, very little advance has been made. A number of studies failed to justify the optimism expressed in Kolata's article. On 30 May 2002 an Associated Press story on the testing of the two drugs read, "So far, six medicines based on his theory have finished the final rounds of human testing. Each medicine was given to hundreds of terminal cancer patients. And each failed to help in any meaningful way" (http://www.intelihealth.com/IH/ihtIH/WSIHW000/333/7228/350651.html).

One of the most significant points of criticism was that the piece should not have been published on the front page. The argument is that no matter how many qualifiers you place in the article, the mere fact of its placement on the front page makes it seem like a major breakthrough. Readers know that stories on the front page, larger headlines, and stories higher up on the page imply greater significance. Editors and science writers should be aware of the impact that a story's placement might have on the way people interpret it.

The internal structure of the story is also important. In the line starting "Within a year . . ." the focus is on the "cancer patient" right until the end of the sentence where "- in mice" is added. It should be acknowledged that the headline does mention the word "mice", but nevertheless this sentence as well as the headline is written in such a way as to place the emphasis on the possibility of a cure for humans. Consider "hope", "cautious awe", "eradicate" and "no obvious side effects". Kolata was pressing all the necessary buttons to get cancer sufferers excited.

About Kolata's lead, Michael Shapiro wrote in the *Columbia Journalism Review* (*CJR*): "The opening was not, strictly speaking, untruthful: if clinical trials did, in fact, begin in a year then the first human subject would indeed be injected with one of the new drugs, angiostatin or endostatin. But it was misleading in that it hinted, quite broadly, that with this vaunted injection the curing could begin (Shapiro 1998).

Shapiro continues by saying:

> Whether a 'breakthrough' will herald 'the cure' is an inevitable journalistic question. But it is the wrong question - wrong in that it seeks an answer that no responsible oncologist can offer, and wrong in that, by inviting overstatement, it profoundly undermines the great value of the discovery at hand. The question of 'the cure' limits the reporting. Reporters might be cynical and suspicious, rightly forcing scientists to make their cases. But the best that they can then hope for is a story that states a possibility of enormous potential, followed, at turns, by disclaimers, qualifiers, and quotes of awe and admiration (Shapiro 1998).

The paragraphs following Kolata's lead contain a number of qualifiers, and Kolata devotes a significant amount of space to scientists advising caution, and the obvious observation that curing mice and curing humans are two very different things. Consider, for example:

> But even the drugs' discoverer, Dr. Judah Folkman, a cancer researcher at Children's Hospital in Boston, is cautious about the drugs' promise. Until patients take them, he said, it is dangerous to make predictions. All he knows, Dr. Folkman said, is that 'if you have cancer and you are a mouse, we can take good care of you' (http://query.nytimes.com/search/article-page.html?res=9F04E6D6113EF930A35756C0 A96E958260).

However, she then continues as follows:

> Other scientists are not so restrained. 'Judah is going to cure cancer in two years,' said Dr. James D. Watson, a Nobel laureate who directs the Cold Spring Harbour Laboratory, a cancer research centre on Long Island. Dr. Watson said Dr. Folkman would be remembered along with scientists like Charles Darwin as someone who permanently altered civilization (http://query.nytimes.com/search/article-page.html?res= 9F04E6D6113EF930A35756C0A96E958260).

A paragraph such as this one recontextualises all the qualifiers in the piece. One could argue that if a Nobel laureate says there will be a cure in two years, it must be quite likely. However, this was not the case. A paragraph such as this one looks suspiciously like throwing someone a life jacket with a hole in it.

On the other hand, one might argue that Kolata is simply giving us both sides of the argument. Thus the question comes down to something much more fundamental, and that is: to what extent we should take responsibility for the ways in which our work might be interpreted? There are no clear-cut answers.

In the above case, I would like to argue that the quote would quite obviously have inspired hope in cancer sufferers - and that there was no real basis for this hope. The fact that a prominent scientist says something does not make it true. At the very least, such statements could have been held back until further studies had been done.

The particular case is made more interesting by Watson's claim that he was misquoted. In a letter to the editor of the *New York Times* he wrote, "Ms. Kolata reported that I predicted that Judah Folkman would cure cancer in two years. My recollection of the conversation to which she refers, however, is quite different. What I told Ms. Kolata, at a dinner party six weeks ago, was that endostatin and angiostatin should be in NCI clinical trials by the end of this year, and that we would know about one year after that whether they were effective" (West 2000).

Misquoting is such a basic sin in the world of journalism that one hardly need elaborate on it. One might ask why a respected journalist like Gina Kolata might do such a thing. Of course it had the effect of further hyping the copy and making it more exciting. There is no clear answer. The possibility of vested interests has been suggested.

The *Columbia Journalism Review* (*CJR*) reported:

> In the days that followed, Kolata, after a meeting with her editors, withdrew a book proposal on Folkman and his work that her agent, who convinced her to submit it after the piece ran, believed could have netted her $2 million (Shapiro 1998).

Although the *CJR* did not suggest foul play, the possibility is definitely a real one.

The *CJR*, like a number of other publications, pointed out that "the news she had delivered was, in fact, not news at all - the development she heralded had been reported six months earlier, and twice in the *Times* itself" (Shapiro 1998). The piece could not be connected to any new publication, press release, or research results. In effect it was old news, touched up and slammed down on the front page of the *New York Times*. The question has to be asked: why?

Kolata's book proposal and vested interests like those of stockholders might have played a role. The story sparked a dramatic rise in the stock prices of biotech companies involved in the research.

On the other hand one could, of course, blame a number of factors internal to the newsroom. Things like a lack of important stories on the particular day, the need to make a splash with the story before anybody else did (although this was not the first time the story was published, it was the first time a big deal was made of it), and also the possibility of ignorance amongst the editors as to the story's consequences.

Be that as it may, the story was not run out of a need to inform accurately and responsibly. Had these values been dominant, there would have been absolutely no reason for the story to appear on the front page of the *New York Times*.

2.3. Coffee

When asked whether coffee is good or bad for you, a statistically significant percentage of people would answer either way. Of course few health matters are as simple as "this is good for you, and that bad". Particularly coffee cannot easily be reduced to this binary opposition.

Coffee, like any food or drug, has both positive and negative health consequences. Coffee, as we will see, may help prevent certain diseases, but may also be responsible for some adverse consequences. When there is reported that coffee is good or bad for us, we are faced with a vile reduction of what is really known.

Reporting the results of studies relating to coffee in a "good/bad" way also has other negative consequences. One study might find that caffeine can be related to heart disease; a few months later another study might find that coffee may help prevent Parkinson's disease. In this way, the public can be bombarded with a succession of stories now claiming that coffee is good, and then that it is bad.

This causes some people to lose faith in what they perceive to be science. They deduce that nobody really knows whether coffee is good or bad for us. But the fact is that coffee has both health benefits and adverse effects. This gets lost, however, in the mêlée of "good/bad" reporting that seeks to sell itself by the extremity of its claims.

Consider the following from the *Daily Telegraph*:

> **Seven coffees a day keeps diabetes away**
> *Coffee addicts may gain protection against diabetes in middle age, according to a study published today.*
>
> People who drink at least seven cups every day are 50 per cent less likely to develop the disease than those drinking a couple of cups, a study of 17,000 Dutch men and women has shown (http://www.telegraph.co.uk/connected/main.jhtml?xml=/connected/

2002/11/06/ecncoff08.xml).

This is an excellent example of coffee being reported as good. The suggestion is that seven cups of coffee a day is "good for you". The positive headline is reinforced by the use of the words, "a study . . . has shown". The suggestion is that the study has proven that coffee prevents diabetes. At no point in the rest of the article is this claim questioned; neither are any of coffee's negative effects noted.

As in our previous examples, not enough doubt is expressed. More important in this case, is the lack of context. In terms of the puzzle metaphor, one might say that only one piece is being reported on, and little is said about how it fits into the puzzle. To make responsible decisions about our use of coffee, we are not interested in separate pieces, but in how they fit together. Seven cups of coffee might prevent diabetes, but this says nothing about how seven cups might contribute to the development of arthritis or heart disease.

Consider the following headlines from the BBC:

- "Coffee worries 'groundless'" - 25 March 2002 (http://news.bbc.co.uk/2/hi/health/1892424.stm);
- "Caffeine limits for pregnant women" - 10 October 2001 (http://news.bbc.co.uk/2/hi/health/1591026.stm);
- "Smokers' cancer risk 'cut by coffee'" - 13 December 2000 (http://news.bbc.co.uk/2/hi/health/1067446.stm);
- "Coffee linked to arthritis" - 26 July 2000 (http://news.bbc.co.uk/2/hi/health/850239.stm);
- "Coffee beats tea on heart disease" - 3 August 1999 (http://news.bbc.co.uk/2/hi/health/409915.stm);
- "Caffeine drives up stress levels" - 4 March 1999 (http://news.bbc.co.uk/2/hi/health/290689.stm);

- "Instant coffee, instant buzz" - 21 July 1998 (http://news.bbc.co.uk/2/hi/health/136714.stm);
- "Research links cot death and caffeine" - 27 January 1998 (http://news.bbc.co.uk/2/hi/science/nature/50899.stm).

And from the *Daily Telegraph:*

- "Seven coffees a day keeps diabetes away" - 8 November 2002 (http://www.telegraph.co.uk/connected/main.jhtml?xml=/connected/2002/11/06/ecncoff08.xml);
- "Be careful with caffeine" - 27 August 2002 (http://www.telegraph.co.uk/health/main.jhtml?xml=/health/2002/08/27/hcoff27.xml);
- "Drinking too much coffee 'causes miscarriage'" - 11 October 2001 (http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2001/10/11/ncoff11.xml);
- "Study links coffee to stiffening of arteries" - 3 September 2001 (http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2001/09/03/wleec103.xml);
- "Caffeine cancer benefits dismissed" - 19 June 2001 (http://www.telegraph.co.uk/health/main.jhtml?xml=/health/2001/06/19/hcoff18.xml).

The thirteen headlines above add up to an approximately equal number of positive and negative reports concerning the use of coffee. It is understandable that readers and even journalists might get confused. Thus it is of cardinal importance that the science writer provides enough context when reporting on coffee. Only by providing enough context and not just focussing on one study can a science writer succeed in his informative role.

Consider the following as an example of how these difficulties might be handled. On 4 March 1999, the BBC reported the following:

Caffeine drives up stress levels

Caffeine boosts blood pressure

Drinking four or five cups of coffee a day makes the body act as if it is under constant stress.

Combined with additional work pressures, it can increase blood pressure significantly, leading to an increased risk of long-term heart disease, says a US report (http://news.bbc.co.uk/2/hi/health/290689.stm).

Then, on 25 March 2002, the BBC reported the following:

Coffee worries 'groundless'

Moderate consumption of coffee has no impact on blood pressure - even over 30 years - according to the latest research.

There had been fears that drinking even relatively small amounts of coffee could raise blood pressure levels and perhaps have some impact on health.
However, a study conducted by researchers at Johns Hopkins University suggests that a couple of cups a day may do no harm (http://news.bbc.co.uk/2/hi/health/1892424.stm).

The second story suggests results directly contrary to the first. However, this is indicated by the line, "There had been fears that drinking even relatively small amounts of coffee could raise blood pressure levels and perhaps have some impact on health." Thus the new findings are to some extent placed in context.

The "fears" are however dismissed as "groundless". Once again we are faced with an over-simplification. One study does not prove something conclusively, particularly when it runs contrary to previous studies.

The second story later ventures into a more general discussion on the health risks related to drinking coffee:

However, in general, the jury is still out on the health risks, if any, of drinking coffee.

> Pregnant women in the UK were recently advised to drink no more than four cups a day because of worries that heavy consumption could increase the risk of miscarriage.
>
> A spokesman for the British Nutrition Foundation said: 'Having three or four cups of coffee a day is not going to do any harm - unless you are one of the few people who has a predisposition to be sensitive to caffeine.
>
> 'In pregnancy, having a couple of cups a day has not been shown to be detrimental.'
>
> The caffeine that coffee contains is a stimulant, and in the short term, after drinking coffee, alertness benefits - although once the caffeine 'high' has passed, people may become far less alert.
>
> There have also been warnings that coffee may contain chemicals linked to heart attacks and strokes, although no direct link has been established (http://news.bbc.co.uk/2/hi/health/1892424.stm).

This is an excellent example of how journalists might provide the necessary context. Even though the story started out focusing on a particular study relating to blood pressure, it did not stop there. As an informative piece of journalism, a story like this one is much more useful than the *Daily Telegraph* story we considered above.

Chapter 3 - Analysis, Ethical Implications and Guidelines

In this chapter, we will consider the causes and implications of inadequate coverage of frontier science, as well as guidelines to avoid this. In a sense, this chapter will try to find a synthesis between the theoretical ideas and the practical examples we considered in the previous two chapters.

Once again it should be pointed out that the purpose of this paper is not to offer conclusive answers or find sollutions; rather, it is simply to enlighten the issues, and thereby empower journalists to make more responsible and informed decisions. The aim is thus to elucidate the complex and difficult position journalists find themselves in when confronted with claims from the frontiers. As such the intention is to alert journalists to their social and ethical responsibility. I intend to show that the notion that science journalists "simply report" the news, is misguided.

3.1 Roots of Misleading Reportage

A number of factors might be seen as contributing to misleading reportage. In this section we will examine a number of the tensions and pressures facing the science journalist.

3.1.1 News Values

One of the most fundamental considerations for a journalist is the question: "What is news?" A number of varying answers can be given to this question. Nevertheless, we find that most media institutions report on approximately the same kind of things. One might say there seems to be a generalized perception of what news is. Factors like conflict, proximity, novelty advances, etc. seem to be generally accepted.

When the question is asked: "What is news in science?", things become a bit more problematic. Here there emerges a clear tension between informing and entertaining, or between writing to report as accurately as possible and writing to sell as many copies as possible. So in the *New York Times* cancer story considered in the previous chapter, the dominant value was entertainment. Even though the story contained a lot of information, its placement and evocative language were more prominent.

A story is not simply either informative or entertainment-centred. Of course a story can unproblematically be both, yet often there exists a tension between the two. An excellent example can be found in the vitamin supplements case considered in 2.1. Had the stories not carried headlines such as "Vitamin pills a waste of time", the issue would not have attracted as much attention as it did. More informative headlines might have conveyed more doubt and mentioned that the study only dealt with high risk individuals. Though such a story would have be more accurate, it would not have sold as well.

In a sense, we are dealing with the scientific need for accuracy and the journalistic need to sell papers. The tension was described as follows in *The Lancet*:

> To scientists, research becomes reliable, and therefore newsworthy, through replication and endorsement by professional colleagues. Research findings are tentative, undigested, preliminary - and therefore not newsworthy - until they are certified by peers to fit into the existing framework of knowledge. For journalists, by contrast, established ideas may be 'old news', and of far less interest than fresh or dramatic, though possibly tentative, research (http://www.thelancet.com/journal/journal.isa). [N16]

One might say that, according to journalistic news values, frontier science is news and textbook science is not. Indeed, most reported science tends to be from the frontiers. But claims from the frontiers are unreliable and have by definition not been sufficiently tested; most science stories in the media should carry a substantial amount of qualifiers and communicate doubt. But doubt and qualifiers do not sell, and thus the need to entertain often overshadows the need to communicate the necessary uncertainty.

The challenge facing the journalist is thus to write as entertainingly as possible, without compromising on accuracy. Since science, and particularly medicine, impacts directly on people’s lives, the tension is endowed with an ethical weight.

3.1.2 Pressures in the Newsroom

Within the nature of the newsroom and the nature of particular forms of media, there are built-in constraints on what a story can look like. A newspaper story usually has to have a short headline and the length of the story itself is limited. On a certain day a story might be allowed more room than on another, due to what is going on in the rest of the paper.

For example, an editor might allocate 400 words for a story on some new research. The research might be quite complex and hard to explain. The writer might struggle to convey the necessary doubt and place the piece in perspective within the limited space. He might also struggle to find experts to appraise the research critically. Having done his best, he may still see the story in the next day's paper cut to 300 words, with a misleading headline slammed on top of it. But by now, the journalist is already facing a new day's stories. Pressures such as these make it hard to write accurately and responsibly.

In a study aimed at elucidating constraints on improving the informative value of medical reporting in the mass media, a group of Swedish researchers found the following:

> We identified nine barriers to improving the informative value of medical journalism: lack of time, space and knowledge; competition for space and audience; difficulties with terminology; problems finding and using sources; problems with editors; and commercialism. Lack of time, space and knowledge were the most common obstacles. The importance of different obstacles varied with the type of media and experience. Many health reporters feel that it is difficult to find independent experts willing to assist journalists, and also think that editors need more education in critical appraisal of medical news. Almost all of the respondents agreed that the informative value of their reporting is important (http://www.presswise.org.uk/ Health%20report%20survey.htm).

Many of these factors will not change. For science writers to have more time and space, the essential nature of contemporary media would have to change. The competitive culture between publications makes immediacy essential. Lack of space is an unavoidable reality in most publications.

There are some things, however, that can be changed. Through good networking it might be easier to find experts to comment on specific matters. Information concerning terminology and the availability of reliable background knowledge could also be improved. Relationships with editors could improve if editors themselves could come to a better understanding of science.

More specific problems intrinsic to the nature of, say newspapers, are the brevity of headlines. Particularly in science stories, short headlines can be misleading.Writing "Vitamin pills a waste of time" is short and captures the attention. In contrast, a headline such as "Antioxidant vitamins: no effect on disease in high-risk people?" would be considered too long and uninteresting by most editors. Thus, in this case, the convention to make headlines short and catchy might well have contributed to the barrage of misleading reports surrounding the particular study.

Similarly, the internal structures of stories also show a degree of convention detrimental to the accuracy of reporting. The lead paragraph of most stories tends not to contain qualifiers. In this paragraph, the emphasis is usually still on capturing the attention of the reader. If a reader were to read only the lead paragraph, he would be severely misled.

There also seems to be a tendency to keep qualifiers or critical comments for the last few paragraphs of an article. If they were right at the top, one might argue that fewer people would read the article. Thus it once again comes down to accuracy vs selling the story. Subscribing to the convention, most journalists choose the latter.

3.1.3 Uninformed Reporters

Inadequacies in science reporting might also relate to the fact that many science writers do not possess a good enough understanding of the working of science, or any actual scientific knowledge, and as a result lack the ability to assess the reliability of particular claims.

Science is a specialised field and requires specific knowledge. A health reporter needs to have a good understanding of human biology. One who does not would be more likely to report inaccurately or fall victim to fraudulent claims. A journalist who has a thorough knowledge of his field can also work faster and ask more relevant questions. Lack of funds and time might however force journalists to report on fields of which they know little and thus produce inaccurate stories.

But more important than actual scientific knowledge, is knowledge of how science works. Journalists who believe that science deals in facts, that frontier science is reliable, or that successful scientists can speak for science as a whole, are more likely to report inaccurately than those who have a better understanding of these issues.

A responsible and informed journalist can no longer hide behind the defence that he is "simply reporting the news". As in other fields, science writers cannot report everything. They have to select from a large number of journal articles, press releases, and so on. But this selection needs to made according to some criteria. Thus even at this early stage news values are at work.

For instance, to report a claimed "instant cure for AIDS" might at one level be considered newsworthy. But the fact that someone made that claim does not mean you have to report it. If the claim was made by a marginal scientist working on his own without offering much evidence for his claims, most editors would not run the story. If the claims however originate from a research article in *Nature*, it would probably make headlines worldwide.

The point is that as a science writer you make selections, and that these selections are neither neutral nor objective. The same could be said for quoting scientists. On one level it makes sense to say "according to this and this study", or "according to this and this scientist"; but to imagine that this frees the journalist of responsibility, is misguided. By choosing to use certain quotes, you are choosing to give voice and prominence to those quotes. When you write in your lead paragraph, "According to X, AIDS will be cured in three months," you are giving voice to that claim, and by quoting it, you are implying that it might be credible. Thus, by shirking his responsibility the science writer becomes more likely to report inaccurate claims or fraudulent science.

3.2 Ethical and Social Implications

To reinforce the claim that the journalist has an ethical responsibility, we will consider some of the negative consequences brought about by inaccurate or misleading reportage.

3.2.1 Stimulating Unreasonable Hope

The *New York Times* article examined in 2.2 provides an excellent example of how a medical story can stimulate hope. The story's placement on the front page and the alleged quotes from James Watson made the claim that a cure might be just around the corner seem credible. As we have seen, this was not the case, and a lot of people were conned into focusing their hope on something without substance.

Cure stories tend to sell well, which is why there are so many of them. People tend to get over-enthusiastic and forget that science, particularly medicine, progresses in a step-by-step manner. Cures are not discovered overnight, and you can only really know whether something is an effective cure after it has undergone extensive testing.

That is not to say particular advances in the search for a cure should not be reported. The focus, however, should be on keeping the particular advance in context. It should be made clear that news from the frontiers is unreliable.

Many stories do carry the necessary qualifiers and caviots. This is essential, but often they are buried at the bottom of the story. Even though a reporter might try to present all sides to an issue, the exact wording and structure of the article also favours particular interpretations. Thus even though the reporter might not explicitly be choosing sides or judging the reliability of results, the story usually implies that one side is right, or a certain claim, accurate.

Some journalists might argue that one cannot be held accountable for how people interpret your article, arguing that different people might interpret a single story quite differently. Yet when one considers examples such as those in chapter 2, it becomes clear that the implicit messages of the stories are quite clear and that different people would probably interpret them similarly.

Writers know where they are placing the emphasis, what they are saying in the lead, and what they are keeping for the last paragraph. Reporters choose where they want to place the focus, and particularly in the case of reporting cures this emphasis is often misplaced, with negative consequences to those who suffer from the particular affliction.

3.2.2 Impact on health

Stories like those relating to vitamin supplements (2.1) might cause some people to stop using vitamin supplements. Considering the fact that a review article in the medical journal *JAMA* recommended that everybody should be taking some form of vitamin supplements, the claims in the British press might well be encouraging information detrimental to the health of their readers.

The problem in the particular case is that of generalization. The *Lancet* study did not suggest that vitamin pills are useless. Nevertheless, it was reported as such. Little emphasis was placed on the specific context or perimeters of the study. There is no plausible justification for saying vitamin pills are useless, except that it would sell more papers. When this is weighed up against the possibility that the report might encourage habits detrimental to readers' health, surely something unethical is happening.

In general, the media seems uninterested in such indirect consequences. The Swedish research referred to earlier, quotes a journalist as saying, "Editors are not interested in what is accurate and what isn't accurate. As long as it doesn't kill anybody, they're not bothered if it's not actually spot on" (http://www.presswise.org.uk/Health%20report%20survey.htm).

3.2.3 Impact on Scientific Literacy

In the same way as science writing can spread misconceptions concerning health and cures, it can spread misconceptions in other fields of science. In these fields the negative impact on people's lives is obviously not as great, but one could argue that bad science reporting in some ways acts to the detriment of scientific literacy.

If newspapers report that eggs are good for you one week and bad a few weeks later, you are bound to take the next story on eggs less seriously. Thus you find people saying, "The scientists don't really know. So I will just carry on as I am." While scientists cannot provide final answers, they do know more than what is suggested by all the conflicting reports, since they can give reliable information about the health risks and benefits associated with eating eggs. As a result, a review article on the health consequences of eggs is bound to be more reliable than any particular study.

As Bauer pointed out, the ability of science to change and adapt to new evidence is not a weakness but a strength which allows it to become more reliable. Part of the problem in this case is that frontier science is not being reported with the necessary scepticism and context. The fact that a study is the most recent does not make it the most reliable. Once again, it all comes back to the tension between informing and entertaining. If the purpose was to inform, stories would be written from within the context of other stories on the same subject, allowing the reader to draw more accurate conclusions.

3.3. Guidelines and Suggestions

Having evaluated various aspects of what can go wrong in the reporting of frontier science, I will now suggest a number of guidelines for dealing with these problems and their implications.

Reporters need to:

1. Have a good understanding of how science works. In this regard a course in Science, Technology and Society is advisable. If this is not possible, a number of books on the matter can be recommended. Of these, Henry H. Bauer's *Scientific Literacy and the Myth of the Scientific Method*, John Ziman's *An Introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology*, and Carl Sagan's *The Demon Haunted World*, are particularly informative.

2. Have knowledge of their specific field. That is to say, someone who reports on medical matters should have a good understanding of medicine and biology. University degrees in the particular fields are advisable.

3. A critical mindset. Due to the vested interests, fraudulent and unreliable claims that are so prominent on the frontiers of science, journalists cannot afford to take things at face value. They need to ask all the tough questions and start from the assumption that a particular piece of research is not reliable, rather than assuming that it is.

Journalists who fulfil these criteria would still be faced with the various pressures within the newsroom. They would, however, be able to handle these pressures much more responsibly than someone who does not fulfil the criteria.

3.3.1 Story-Specific Guidelines

The following checklist provides a few basic elements which I suggest should be considered when writing a frontier story. If all these questions can be satisfactorily answered, the likelihood of errors in the story would be much smaller.

1. Is the study design valid?
2. What do the study results actually suggest?
3. Am I generalizing?
4. What research or review articles have been published on the same topic?
5. Am I writing the story in context?
6. Do I have critical opinions from experts not involved with the study?
7. Am I communicating the necessary doubt and uncertainty?
8. What am I saying implicitly?
9. Who is funding the study?
10. Which parties have an interest in the research?

A similar list recently appeared in the *Columbia Journalism Review*. It outlined what they called the seven deadly sins of medical reporting. Even though the list was written with medical reporting in mind, most of it is also applicable to the wider field of science reporting. The seven deadly sins are as follows:

1. Accentuating the positive and ignoring the negative
2. Generalizing from anecdotes
3. Failing to recognize weaknesses in scientific studies
4. Failing to interpret the numbers
5. Failing to disclose sources' conflict of interest
6. Confusing an intermediate out outcome with a health outcome
7. Offering tips that may be misleading or harmful (Lieberman 2001).

3.3.2 Wider Suggestions

The Swedish research referred to earlier identify lack of time, space and knowledge as the three major constraints to improving the informative value of science reporting. A number of suggestions were made as to how these problems can be countered (http://www.presswise.org.uk/ Health%20report%20survey.htm).

Educating editors as to the nature and particular difficulties facing the science journalist might help to alleviate the problem of space, and to some degree time. Getting editors to go to the trouble of an STS course will, of course, not be easy (http://www.presswise.org.uk/ Health%20report%20survey.htm).

A further suggestion pertains to the increased development of reliable online recourses. When writing a story under deadline, such a resource would be invaluable for quick and accurate information (http://www.presswise.org.uk/ Health%20report%20survey.htm).

Of even greater importance is the need to improve the relationship between scientists and journalists. This will be of particular value when trying to place a new study in context. The practical reality is that journalists often lack the technical details and are reliant on experts to judge the reliability of specific claims. Developing more adequate lines of communication might not be so easy.

Finally, I would like to suggest that it is advisable to include a chapter on "How science works" in school textbooks. Such a chapter would at the very least empower a small number of people to think more critically about what they read in the media. If the distinction between frontier and textbook science could become more widely understood, much of the uncertainty brought about by misleading reportage would be eliminated.

3.4. Conclusion

There are a number of pitfalls or ways in which reportage from the frontiers can be inaccurate or misleading. We identified a number of factors contributing to this, and considered some consequences of inaccurate or misleading reporting from the frontiers.

By pointing out these ethical and social implications, the need for responsible and informed journalism becomes obvious. Accordingly we argued, and illustrated, that a better understanding of how science works, amongst other factors, may contribute to more satisfactory reportage.

This is not to say that an informed journalist would necessarily act responsibly. The various forces and pressures from within and without the newsroom often play a significant role. Thus the value of entertaining is often placed above that of informing. Competition, the need to sell the paper, lack of staff, and the need for immediacy are all realities that the science journalist faces, and much of what goes wrong is simply a factor of this.

The point, however, is that the science writer should be called to his responsibility. Reporting accurately and responsibly from the frontiers is not easy. It nevertheless has social and ethical consequences, and it is an increased awareness of this fact that we tried to clarify.

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